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Pesticide Container Processing in Commercial Reconditioning Facilities

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pesticide container processing in commercial reconditioning facilities

a current report on solid waste management

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PESTICIDE CONTAINER PROCESSING

IN

COMMERCIAL RECONDITIONING FACILITIES

This report (SW-88d) part of a study
conducted under EPA Demonstration Grant 5-G06-00222 was written
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Drum Processing in Commercial Reconditioning Facilities

Summary

The drum reconditioning industry in the United States currently reconditions many pesticide containers. Cost incentives to recondition pesticide containers exist, but the problems of residual pesticide and waste-water treatment require study. Reconditioning is accomplished by two different methods — use of heated chemical solutions or incineration followed by an abrasive treatment. This study addresses the effectiveness of chemical processing.

Drums formerly containing phorate, disulfoton, carbaryl, diazinon, 2,4-D, and 2,4,5-T were tested for pesticide content as received, after triple-rinsing with water, and after plant processing. The residues were measured from wedges cut from the containers. The weight of the wedge was related to the total weight of the container; in turn, the pesticide residue of the wedge can be related back to the total pesticide content of the container.

In the case of phorate, 95 percent of the pesticide was removed with both triple-rinsing and plant processing. Each independent process removed about 60 percent. The amount removed by each process was variable indicating possible processing inconsistencies. Similar results were obtained from disulfoton drums. Triple-rinsing and plant processing of chlordane containers leave about the same residue by each method. As chlordane is water insoluble, a solvent pre-wash is indicated. Over 90 percent of the phenoxy herbicides were removed by triple-rinsing alone.

Tests on 5 gallon containers yielded about the same proportion of residue as 55 gallon containers. Wash solution degradation is discussed briefly.

Drum Processing in Commercial Reconditioning Facilities

Introduction

A well-established adjunct to production, manufacturing and materials transport in the United States is the container reconditioning industry. With one or more plants located in most large population centers, the industry renews for resale a large volume of 30 and 55 gallon containers for a wide variety of industrial uses including oils, chemicals, paints, adhesives and many other products. Prior to the environmental movement, many types of pesticide containers were regularly processed in these plants by the normal processing procedures.

With increases in costs of raw materials, labor, and energy, it appears logical to expect that recycling of containers through such facilities will increase in importance and that procedures will be found to enable processing of pesticide containers in such facilities in a safe and economical manner.

This paper covers one phase of several related which addressed collection and impoundment, preprocessing, movement of containers to commerical reconditioning facilities or to scrap, processing in commercial facilities, washwater treatment, and container scrap off-gas treatment.

Two main methods of container reconditioning are discussed here:

1. Processing by use of chemical solutions at elevated temperature combined with mechanical abrading and reshaping processes.

2. Processing by use of incineration and reshaping procedures combined with sand-or-shot-blasting as required by container condition.

The first procedure lends itself to pesticides of high solubility and low toxicity where residuals would not be critical for non-food or feed uses.

The second procedures lends itself well to pesticides of high toxicity and/or low solubility if adequate controls are maintained on incinerator temperatures such that pesticide materials are completely combusted to elemental components.

The present project was designed to explore the potential of commercial facilities to reduce pesticide residuals by use of the first method above using chemical and mechanical means.

Specific objectives were:

1. To develop sampling and analytical methods for rapidly determining the amount of residue in a container.
2. To determine the amount of residue remaining in containers after processing by various methods.
3. To determine the concentration of pesticide in the wash solutions.
4. To conduct preliminary investigations into wash solution treatment processes.

Commercial Reconditioning

Facilities of the Vann Barrel Company of Portland, Oregon, were utilized in the studies. This company, one of two reconditioners in Portland has been in operation for many years and, while all types of drums are processed, oil drums of several large oil companies make up the bulk of the processing business. A schematic layout of the plant is shown as Figure 1 with arrows showing the movement of drums through the plant.

Unit processes included in order of their use in this particular plant are:

1. Inside caustic flush
2. Submergency in caustic solution (Solution 1-2% Sodium Hydroxide solution at about 200°F.)
3. Spray rinse
4. De-dent
5. Chain interior
6. Straighten chines
7. Test for leaks
8. Inside steam-spray rinse
9. Inside syphone dryer
10. Spray-paint exterior
11. Storage

SCHEMATIC LAYOUT

OF A

TYPICAL COMMERCIAL DRUM RECONDITIONING PLANT

VANN BARREL COMPANY
PORTLAND, OREGON

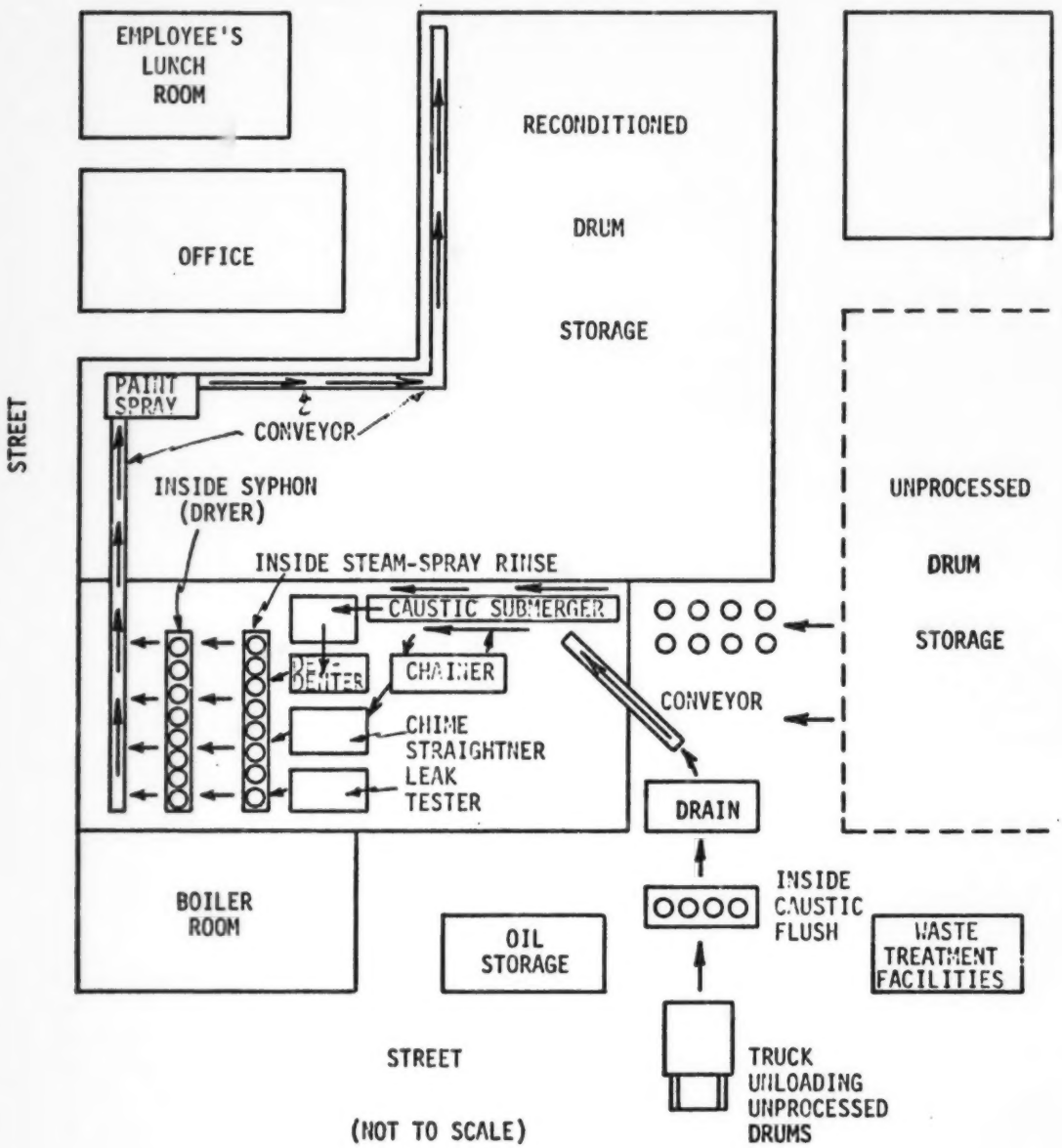

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Fig. 1

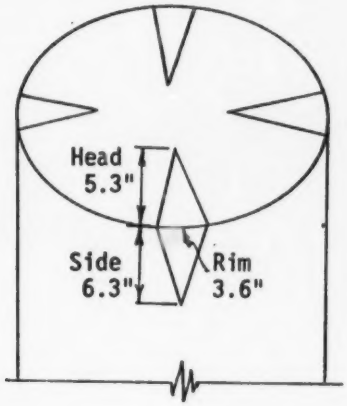

Figure 2 Size, shape, and location of wedges cut from 55 gallon drums.

Container Processing:

In most cases the drums were rinsed with water three times prior to plant processing to simulate recommended field procedures. Pennwalt 91 and Oakite Ruststripper, commercial cleaning preparations, were both tried as cleaning agents in the wash solutions. The amount of cleaning agent in solution was adjusted to make the wash solution 1 or 2% caustic. The five gallon diazinon containers were run through the processes manually, while all other containers were processed through the plant using the normal mechanized equipment available for the larger drums.

Sampling Procedures for Pesticide Content Determinations:

Wedges were cut from the drums of the size shown and at locations indicated in Figure 2. Initially, the containers were sampled as wedges with the weight of the wedge being related to the total weight of the container in order to obtain the total amount of pesticide in the container, as shown in equation 1.

$$P_C = \frac{P_W}{W_W} W_C \qquad (1)$$

Where:

P_C=pesticide content of a container

P_W=pesticide extracted from a set of wedges (grams)

W_W=weight of wedges

W_C=total weight of container

Subsequent investigation into concentration of pesticide at various sites on the interior surfaces of the container revealed that 81% of the pesticide residual was contained in the chime or rim of the container. In order to take this into account, the method of calculation shown in equation 2 was used.

$$P_t = \frac{0.81\ P_W\ (L_t)}{L_W} + \frac{0.19\ P_W\ (A_t)}{A_W} \qquad (2)$$

Where:

P_t=total pesticide in the container (grams)

A_t=total interior surface area of the container

L_t=total length of rim of the container

L_W=combined length of rim of the wedges extracted

A_W=combined area of the wedges

Further simplification of the calculations was achieved by using the ratio of equation 1 and equation 2 to yield a correction factor "Z" as shown in equation 3:

$$Z = \frac{P_t}{P_C} \qquad (3)$$

This factor permits the weight of a standard sized wedge to be related to the total amount of pesticide found in the drum as indicated by combining equations 1 and 3 to yield:

$$P_t = (Z)\frac{P_W}{W_W} W_C \qquad (4)$$

Z values were determined as 0.45 for the 30 gallon container and 0.61 for the 55 gallon container. The total amount of pesticide in each drum was calculated according to equation 4 and was then used as the basis of comparison in this study.

Extraction procedures. Six wedges (Figure 2) 3.6±0.3 inches at the rim by 5.3±0.3 inches long (side H) by 6.3 0.3 inches long (side S) were placed chine down in a 4 liter stainless steel beaker with sufficient solvent to cover the wedges. The solvents used for the various pesticides are shown in Table 1.

Analysis procedures. Chlordane, diazinon, disulfoton, methoxychlor, and phorate extracts were evaporated to near dryness and transferred with hexane to an appropriate volumetric flask and diluted to volume. Usually a second or third dilution was necessary for GLC analysis. The GLC conditions for each pesticide are shown in Table 1. An electron capture detector was used for the GLC analysis.

Carbaryl was analyzed using the method described by Karinen *et al.* (1967). The dichloromethane (DCM) extracted wedges were evaporated to 500 milliliters and the extracted paint material allowed to settle out overnight. A small aliquot (1-10 milliliters) was removed with a pipette and evaporated to dryness in a 10 milliliter volumetric flask. The residue was dissolved in 0.5 milliliter ethanol and the carbaryl and 1-naphthol were determined. Water samples were adjusted to approximately pH 7 and extracted 3 times.

Dichloromethane extracts were analyzed for karathane by the method of Kilgore and Cheng (1963). Water was extracted with DCM at pH3. The DCM was carefully evaporated to dryness and the sample was then redissolved in 4 milliliters of dimethylformamide for color development.

Two milliliters of the 2,4-D and 2,4,5-T sodium hydroxide extracts were acidified to pH 3 and extracted three times with 5 milliliters of ethyl ether. The combined ether extracts were treated with a slight excess of diazomethane, allowed to stand 10 minutes, and boiled on a steam bath to remove the excess diazomethane (yellow color). After appropriate dilution the extracts were ready for GLC. Water samples were adjusted to pH 10-14 to allow hydrolysis and then acidified and extracted as described above.

The total pesticide content of each drum was determined using equation 4 shown previously.

Results and Discussion

Phorate. Although used containers with residuals of several pesticides were used, phorate was the only pesticide for which an adequate number of drums were available for processing and analysis in a systematic manner during this phase of the project. Two different procedures were used in sampling the phorate drums. The first series of drums was sampled such that ten randomly selected drums were sampled before washing, ten were sampled after rinsing three times with clean water (triple rinse), ten were sampled after plant processing, and ten were sampled after triple rinsing and plant processing. The second procedure involved sampling ten drums before washing and resampling the same drums after rinsing and processing.

As may be seen from Table II, each process significantly removed additional pesticide from the containers. Most pesticide was removed when both triple rinsing and plant processing were employed. Using both processes sequentially, more than 95% of the phorate was removed when drums were in reasonably good condition. Either one of the processes used

independently removed more than 60% of the phorate, and had much greater variability than when both processes were used. Although the mean removal was lower for plant processing only, neither process was significantly better statistically, in cleaning ability than the other. The average amount of phorate remaining in the dual processed drums was 1.27 grams per drum.

Assuming that all of the phorate remaining in the drum would be dissolved in 55 gallons of a liquid contained in the drum upon reuse, a concentration of 6.1 parts per million of phorate would result. With the permissible toxicity level for this material taken into account, drums in this condition would be suitable for non-food uses if precautions were taken to ensure that they could only be used in this manner.

When results from containers analyzed before and after is compared for each drum separately, greater variability and apparently less cleanup occurred. The presence of one drum with only 37% decrease in residue with the remaining 9 drums showing a 77-95% decrease indicates that occasionally a drum is either not being properly processed or that there was considerably more residue within the chine that was unremovable by the cleaning methods used.

The average residue removed was 89% leaving 2.63 grams of phorate in each drum. This represents 12.6 parts per million of phorate in 55 gallons of a possible secondary use liquid. A possible explanation for the overall higher amount of phorate present may be due to the fact that these drums were washed after the other two sets of barrels had been processed. Thus the concentration of phorate in the water would have been high and some cross-contamination from the processing solution could possibly have resulted.

Analysis of the rinse water showed that phorate, phorate sulfoxide, phorate sulfone, and traces of the oxygen analog were present in detectable quantities. The majority of residue (about 80%) was found as phorate sulfoxide.

Disulfoton. Table IV shows the results when drums containing an organophosphate similar to phorate were processed. Although the triple rinse appears to have been more effective with disulfoton than phorate, the percent removed for the combined processes is nearly the same for disulfoton as for phorate. The fact that the containers were hand fed through the process did not appear to make a significant difference.

Carbaryl, Chlordane, Diazinon, 2,4-D, and 2,4,5-T. Since a sufficient number of containers were not available to perform the extensive comparisons that were possible with phorate and disulfoton, containers used for several other pesticides were examined only for the amount of residue remaining in the containers. From Tables V and VI it can be seen that significant quantities of pesticide still remain in some of the processed containers. The amount of residue remaining likely depends upon whether the containers were used for formulated material or technical grade material. The formulated pesticides would tend to form stable emulsions while the technical material would be removed only to the extent that it was soluble in the water, hydrolyzed by the base present in process solutions, or physically washed from the container independent of chemical action. Since the carbaryl containers contained an emulsifiable concentrate and the chlordane containers were a mixture of drums containing formulation type and technical grade pesticides, it would logically be expected that higher and more variable residue levels would result from the chlordane containers. The additional fact that carbaryl is readily hydrolyzed and chlordane is not probably accounts for the lower carbaryl residue levels.

Triple rinsing of technical grade chlordane containers decreases the amount of chemical present to essentially that obtained by plant processing.

High residual levels after both types of processing, particularly of drums used for technical grade chlordane, indicates that the material is highly insoluble in aqueous solutions and is susceptible to only slight hydrolysis as mentioned above. In such cases of low solubility and chemical activity, pre-processing of containers with appropriate solutes prior to release from point of use appears to be indicated. This does not hold true, however, for 2,4-D and 2,4,5-T drums as shown in Table V. Processing through the reconditioning plant removed over 90% of the 2,4-D residue remaining after triple rinsing.

Although 2,4-D and 2,4,5-T do not present the toxicity problem to humans which phorate, disulfoton, and diazinon do, other problems resulting from the phytotoxicity of these compounds would limit the reuse of these containers. On the basis of the mean residual in a container, a concentration of 1.26 parts per million would result if all the 2,4-D residues were dissolved in 30 gallons of material in the drum. Considering the variation among the samples, concentrations of 2 parts per million 2,4-D and 2.5 parts per million 2,4,5-T might be expected in a solution resulting from re-use of a triple rinsed and processed drum. This amount of 2,4-D might be sufficient to cause damage to certain sensitive crops if applied after diluting up to four times.

The feasibility of cleaning 5 gallon containers in a manner similar to that utilized for 30 and 55 gallon drums was investigated using empty 5 gallon diazinon cans. The amount of residue remaining in the containers is shown in Table VII. Residues in the processed 5 gallon containers were approximately equivalent to those found for the other organophosphates in experiments with the larger drums. On the average, the cleaned 5 gallon cans had a residual of 12.8 parts

per million diazinon, while cleaned 55 gallon drums contained from 5 to 13 parts per million phorate.

The effectiveness of the extraction procedure used was also determined using the diazinon cans. From Table VII it can be seen that practically all of the diazinon is extracted in two extractions. Less than 0.3% could be extracted with a third extraction. Thus, only two extractions of the wedges were necessary.

Process solutions. Table VIII summarizes the results from analyzing several of the wash solutions used in processing the containers. Pesticides which are easily broken down in 1% caustic show significantly less residue in the wash solutions than the more stable pesticides. Only the acid was measured in the case of 2,4-D and 2,4,5-T. Since the 2,4-D ester was found to hydrolyze completely in the wash solution within 4 hours, the acids are all that one would expect to be present in the wash solution. Experiments using diazinon showed its half-life in the 1% caustic wash solution to be 21 days. Carbaryl in the 1% caustic solution is completely hydrolyzed within 30 minutes. Disulfoton wash solutions contained unidentified peaks (possible breakdown products) when they were analyzed. As has been already noted, the phorate wash was mostly in the form of phorate sulfoxide. Since some hydrolysis products are not extracted with hexane or dichloromethane, they would not be observed using the methods employed here.

TABLE I Extraction and GLC Conditions Used in this Report

Pesticide	Extraction Solvent	GC Column	Temp °C	Flow Rate ml/min	Retention time, Rt minutes
Carbaryl	dichloromethane	Colorimetric			
Chlordane	ethyl ether	5' x 1/4" glass 10% OV-1	245	60	6-18 *
Diazinon	ethyl ether	5' x 1/4" glass 10% OV-1	240	30	3.5
Disulfoton	ethyl ether or acetone	8' x 1/8" glass 7% OV-1	200	25	3.5
2,4-D and 2,4,5-T	4-6% NaOH	6' x 1/8" glass 7% OV-1	170	25	1.6, 2.8
Karathane	dichloromethane	Colorimetric			
Methoxychlor	ethyl ether	6' x 1/8" glass 7% OV-1	245	60	10
Phorate	ethyl ether or acetone	6' x 1/8" glass 7% OV-1	185	25	2.2

* Multiple peaks

TABLE II Removal of Phorate Residues From 55 Gallon Drums

	Unprocessed drum residual, grams	Triple rinsed drum residual, grams	Plant processed drum residual, grams	Combined* residual, grams
	59.8	4.10	1.88	0.389
	24.8	3.98	0.80	1.362
	25.0	10.25	5.61	0.937
	32.6	7.97	7.33	0.335
	46.6	13.62	8.37	0.776
	64.9	6.42	3.99	0.696
	15.9	7.98	7.49	2.072
	44.9	9.05	0.82	1.912
	36.9	15.20	7.39	2.117
	38.2	7.75	3.23	2.061
Mean	39.0	8.63	4.69	1.266
Percent removed	--	77.9	88.0	96.7
Standard error	24.1	1.33	.857	.0527

* Triple rinsed and plant processed

TABLE III Removal of Phorate Residues From 55 Gallon Drums Sampled Before and After Plant Processing

Drum	Before process, residual, grams	After process residual grams	Reduction	Estimated percent removal
A	14.38	3.30	11.08	77.1
C	17.19	10.82	6.37	37.1
D	17.34	3.24	14.10	81.3
E	13.22	2.10	11.12	84.1
F	12.66	2.11	10.55	83.3
G	39.60	2.18	37.42	94.5
H	58.56	3.56	55.00	93.9
I	50.78	2.85	47.93	94.4
J	45.10	2.14	42.96	95.3
K	45.45	2.18	43.27	95.2
Mean	31.43	2.63*		88.8
Standard error S^2_n	32.63	0.04*		
Confidence interval 95%	25.72-37.14	2.16-3.10*		

*Drum "C" excluded

TABLE IV Removal of Disulfoton from 55 Gallon Drums Using Triple Rinse or Combined Processing

	Unprocessed drum residual, grams	Triple rinsed drum residual, grams	Processed * drum residual, grams
	18.2	1.255	0.315
	17.8	1.726	0.364
	19.5	0.296	0.445
	19.7	0.678	0.148
		0.375	0.176
	____	0.114	0.046
Mean	18.8	0.741	0.249
Standard error $\frac{S^2}{n}$	0.222	0.065	0.0038
Confidence interval 95%	17.3-20.3	0.084-1.298	0.009-0.406
Percent removed	--	96.0	98.7

*Triple rinse and plant process

TABLE V 2,4-D and 2,4,5-T Residuals in Processed 30-Gallon Drums

Residual in drums * triple rinsed only		Residual in drums + plant processed only		Residual in drums *+ triple rinsed and plant processed	
2,4-D grams/drum	2,4,5-T grams/drum	2,4-D grams/drum	2,4,5-T grams/drum	2,4-D grams/drum	2,4,5-T grams/drum
1.01	3.25	0.300	0.322	0.077	0.061
10.91	21.71	0.900	1.832	0.132	0.135
0.861	1.67	0.532	0.966	0.251	0.278
6.24	2.25	0.432	0.720	0.106	0.123
		0.732	1.480	0.138	0.188
		0.432	2.106	0.128	0.158
				0.054	0.083
				0.216	0.326
				0.118	0.134
				0.208	0.267
				0.093	0.154
				0.139	0.204
				0.208	0.293
				0.093	0.158
				0.139	0.255
				0.208	0.189
				0.104	
				0.163	
				0.138	
Mean Residual 4.76±4.80	7.22±9.68	0.555±0.222	1.238±0.685	0.142±0.054	0.188±0.077

* Oakite^{R} caustic processing material.

+ Pennwalt 91^{R} caustic processing material.

TABLE VI Pesticide Residues in Processed Containers

Pesticide	Carbaryl grams/drum	Chlordane*+ grams/drum	Chlordane‡+ grams/drum
Mean	0.105	3.10	2.44
Range	0.055-0.148	1.25-8.34	0.290-10.78
Standard error	0.00013	1.17	0.649
Number of drums	6	6	17

*Triple rinsed

‡Triple rinsed and plant processed

+Technical grade

TABLE VII Number of Extractions Necessary to Remove Diazinon Residues from 5 Gallon Can Wedges and Total Diazinon Residues in the Containers.

Sample	First extraction wedges, grams	Second extraction wedges, grams	Third extraction wedges, grams	Total extracted wedges, grams	Total extracted drum, grams
2-7-A	0.113	0.013	0.0003	0.126	0.455
2-7-B	0.030	0.003	<.0001	0.033	0.119
2-7-C	0.055	0.005	<.0001	0.060	0.217
2-7-D	0.081	0.012	0.0003	0.093	0.336
2-7-E	0.090	0.001	<.0001	0.091	0.329
2-7-F	0.099	0.003	<.0001	0.102	0.368
2-7-G	0.026	0.001	<.0001	0.027	0.097
2-7-H	0.046	0.011	<.0001	0.057	0.206
2-7-I	0.015	0.002	<.0001	0.017	0.062

Mean 0.243±0.136

$\frac{s^2}{n}$ 0.0021

Interval (95%) 0.138-0.348

TABLE VIII Amount of Pesticide Remaining in Process Solutions

Pesticide	Grams pesticide	Number containers	Grams generated per container
Phorate	84.01*	30	2.80
Disulfoton	0.183+	48	.004
Chlordane	4222.4+ ‡	22	191.93
Carbaryl (1-naphthol)	28.73+	11	2.61
2,4-D	621.5*	38	16.35

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* Flusher and submerger

+ Flusher only

‡ Technical grade

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